(54) **Telephone call cost calculator**

(57) A calculator for determining and indicating the cost of a telephone call or calls from subscriber apparatus comprises a data processor, e.g. a microprocessor 10, with associate memory means (14—17) for storing program instructions and data defining call charge bands. The charge band is determined by comparing the first digit or first few digits, as necessary, of the dialled number with data in the memory. Timing means including a clock/calendar are provided to select the appropriate charge rate in a charge band. Timing is initiated by means 41, e.g. a press-button operated by the subscriber and/or automatic means determining the completion of a connection or possibly at a predetermined delay time after the end of dialling or sensing of the ringing tone.

   A display 53 selectively displays the current cost of a call or the cumulative cost of calls over a period.
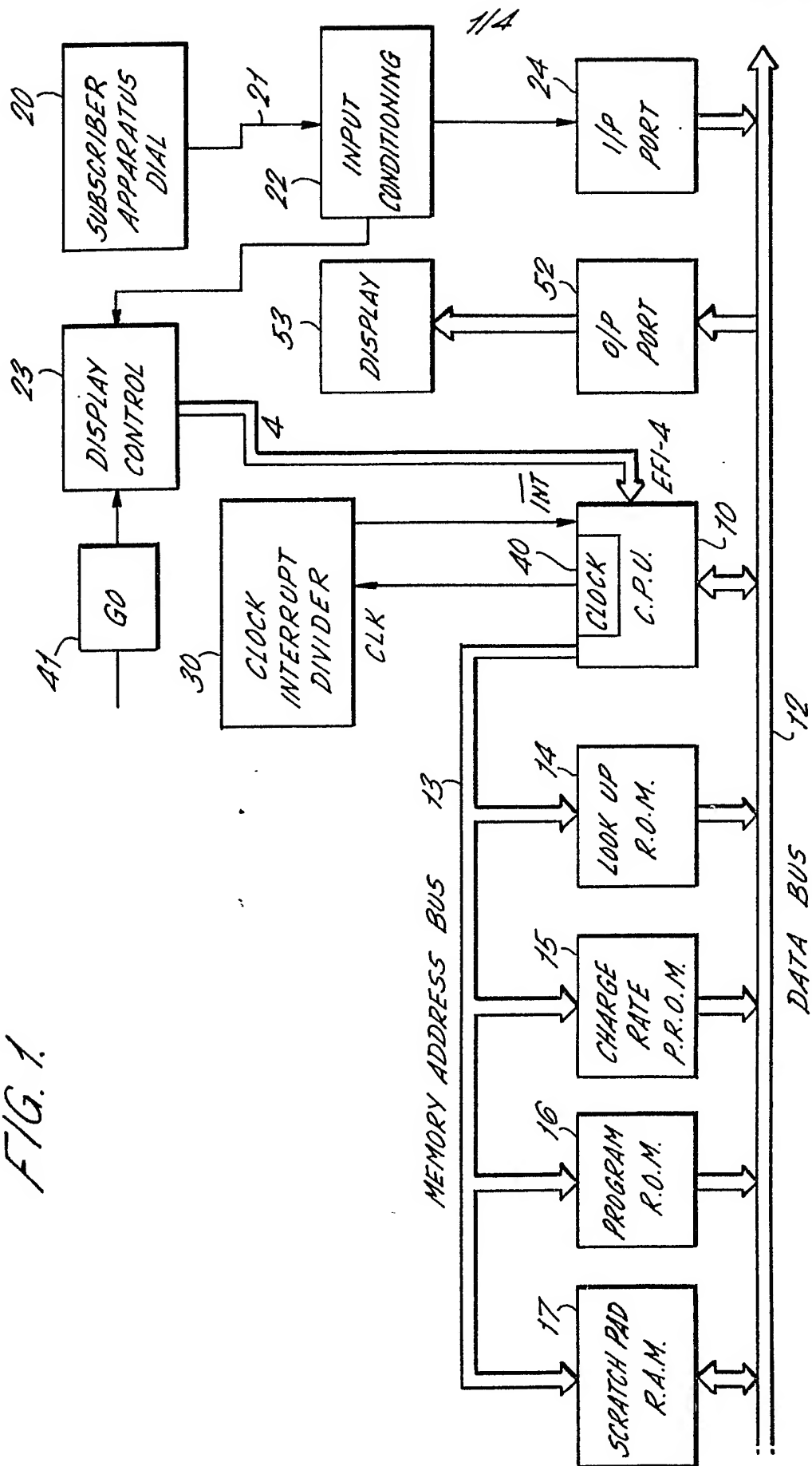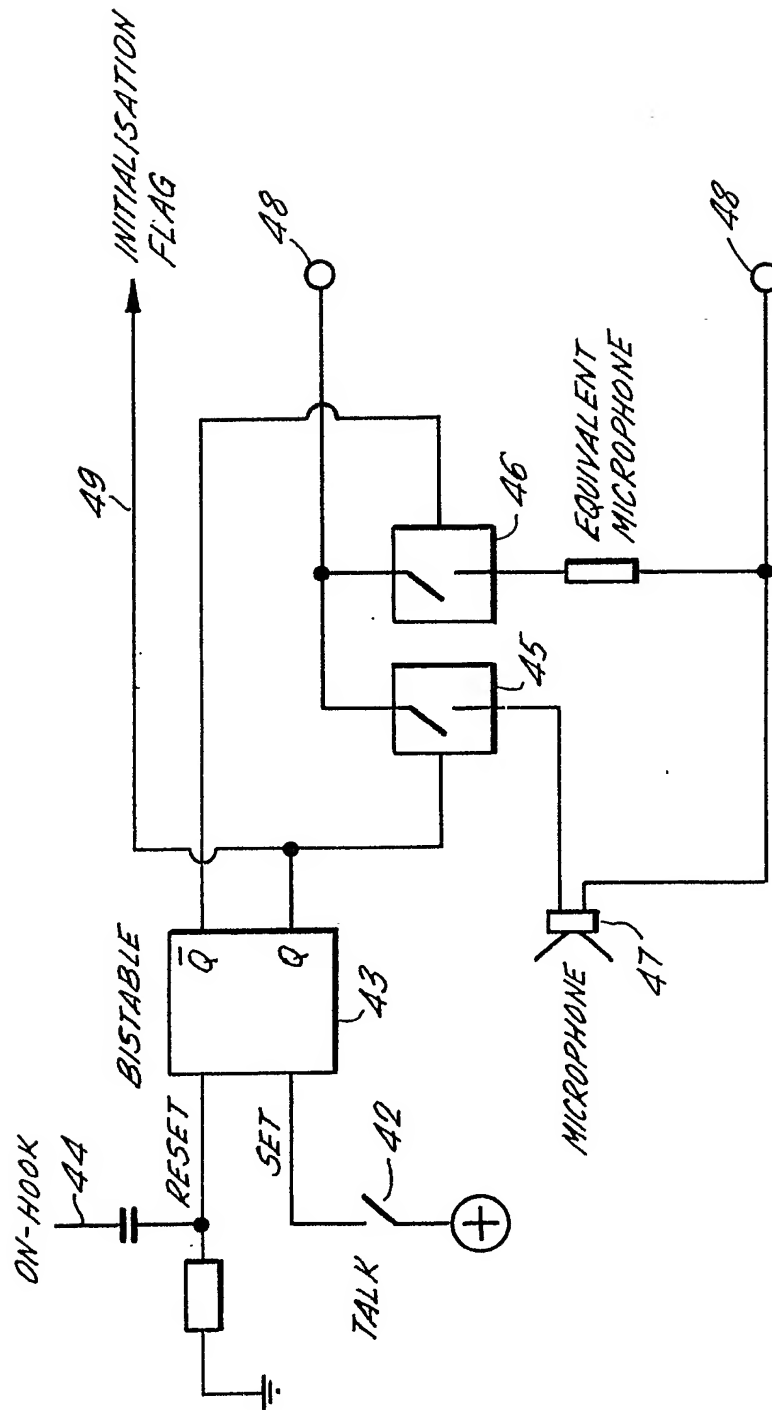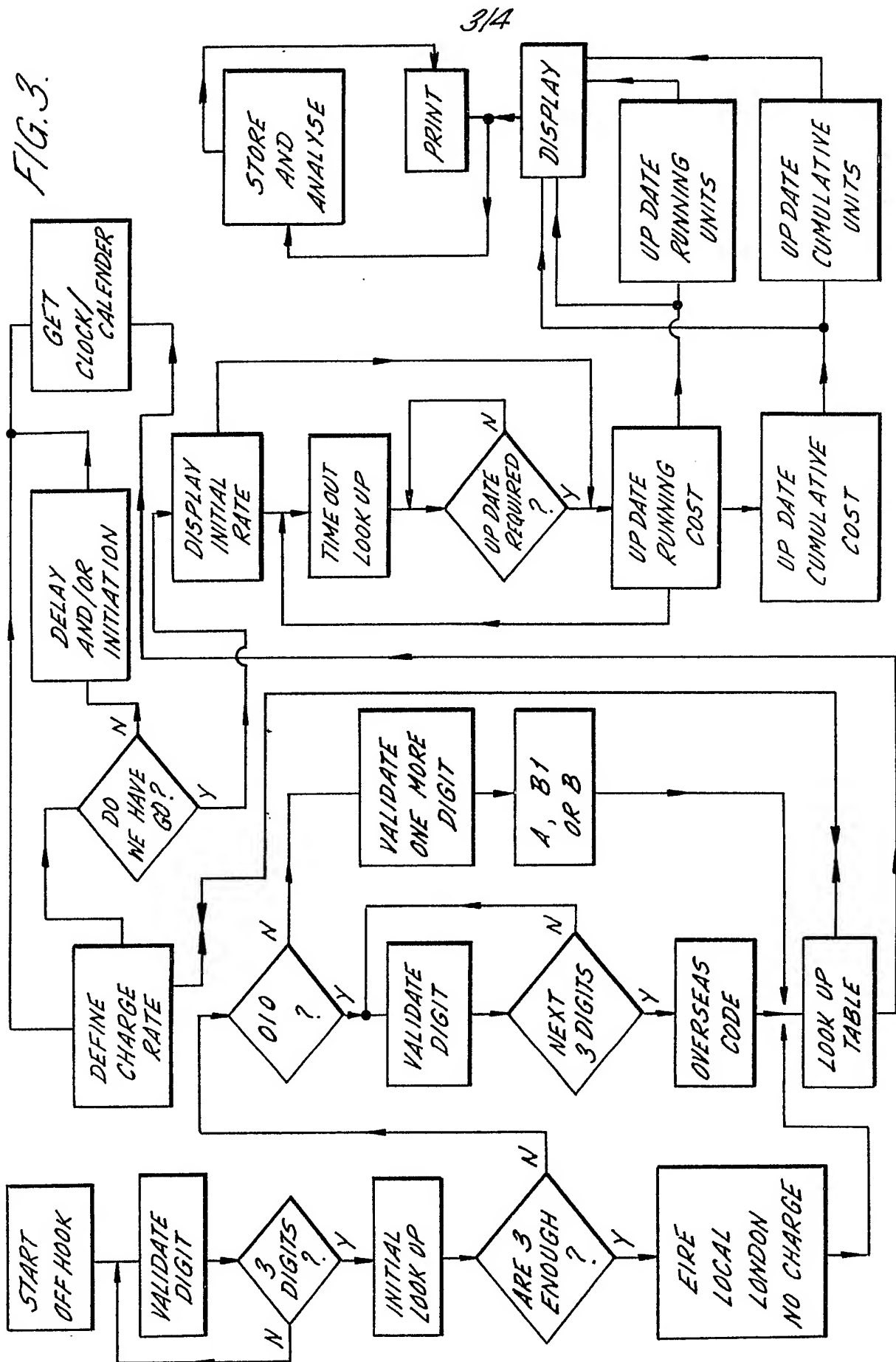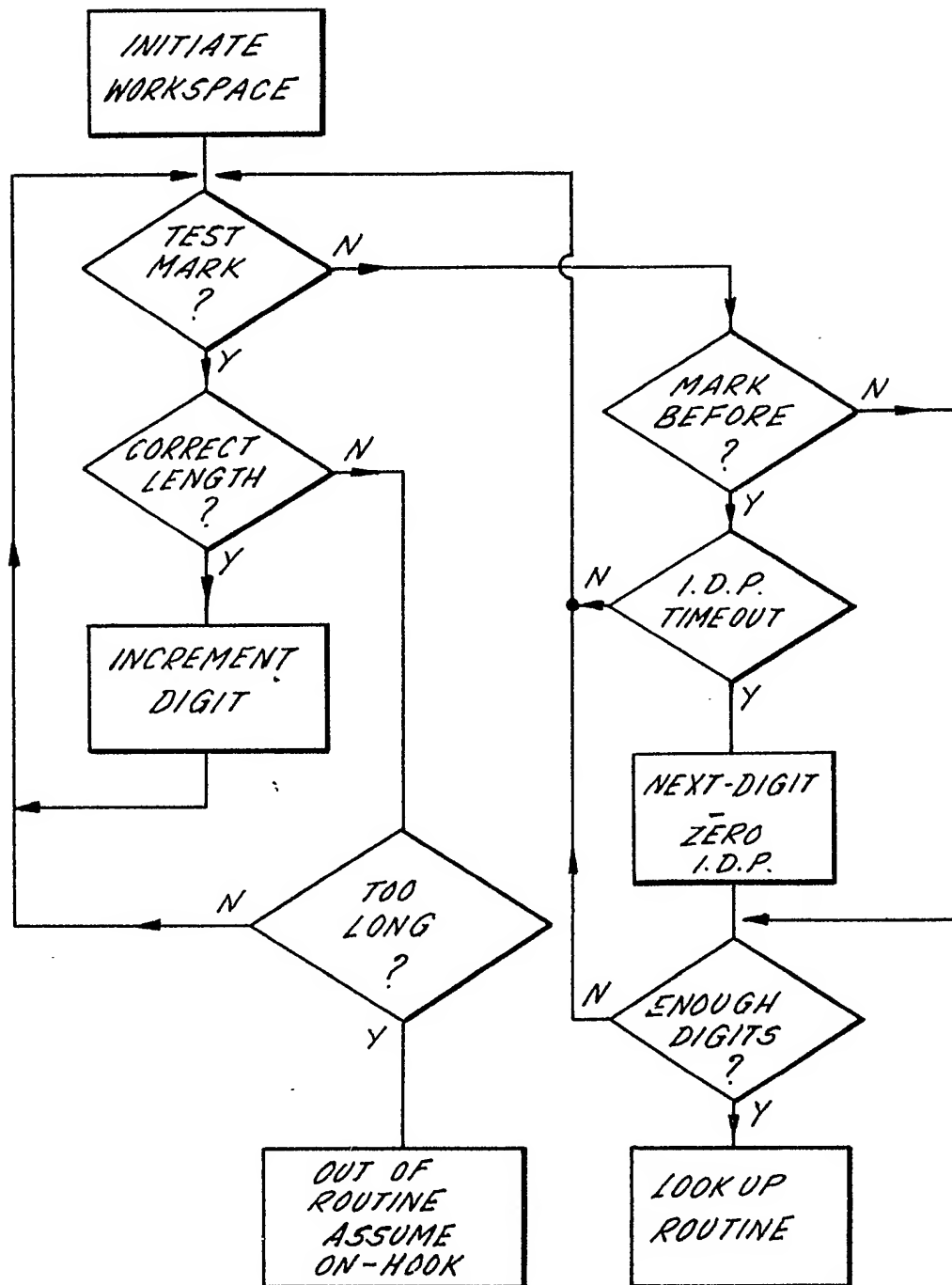

FIG. 1.

FIG. 1.

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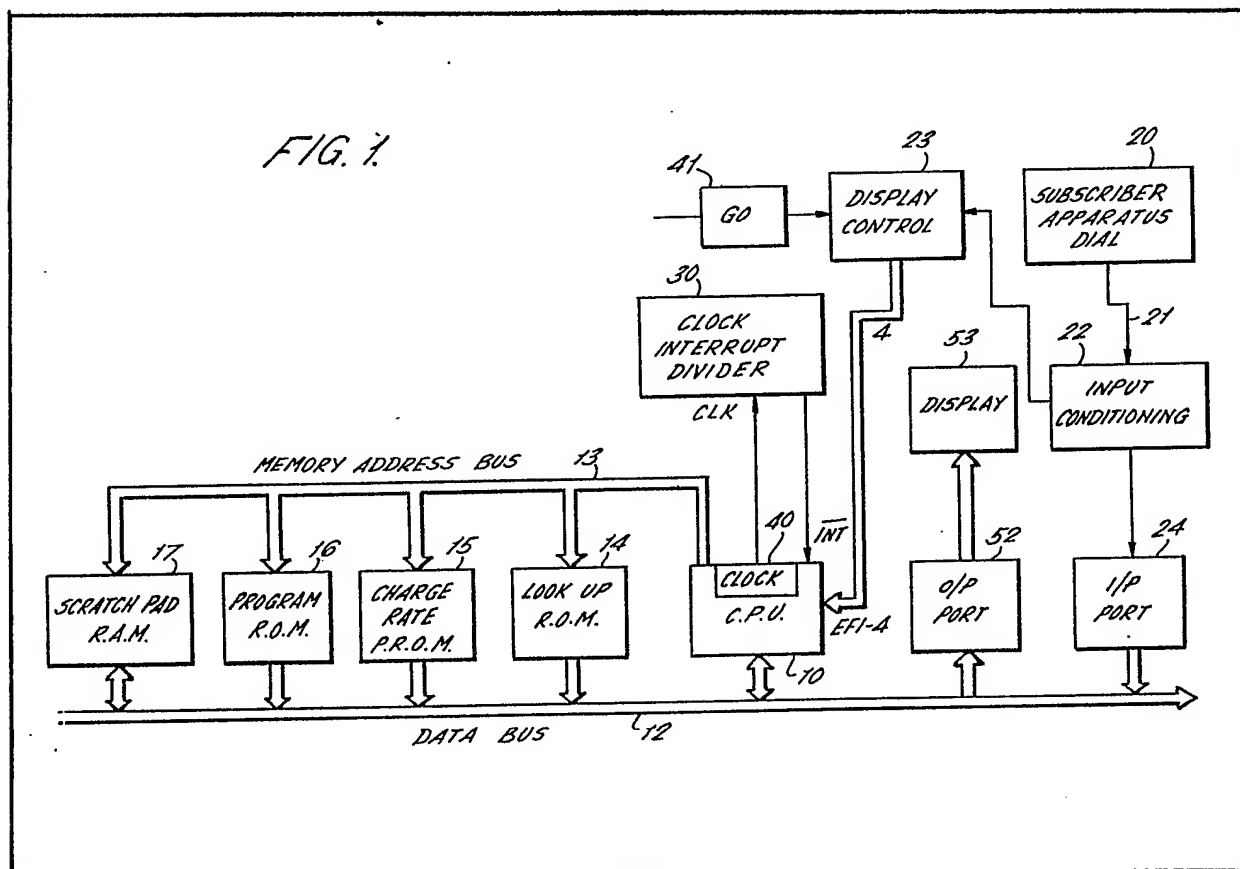
FIG. 2.

FIG. 3.

FIG. 4.

SPECIFICATION
Telephone call cost calculator

This invention relates to a telephone call cost
calculator and is concerned more particularly with
5 the provision of call cost information to
subscribers.

In the United Kingdom, when a telephone call
is dialled directly, that is to say without the
intervention of an operator, metering pulses are
10 generated at the exchange by equipment which is
designed basically to operate meters in the
exchange for the purpose of invoicing this
subscriber. By arrangement with the telephone
authority, it is possible, on payment of a quaterly
15 charge, to have these pulses routed to the
subscriber's line so that they may be counted and
displayed at the subscriber location, either
electromechanically or electronically. The
subscriber can thus obtain an indication of the
20 cumulative cost of his calls and, by noting the
readings before and after making a call, he can
determine the cost of that call. The equipment
required for this purpose however is such that,
due to space considerations in exchanges, the
25 telephone authorities cannot in general provide
such a service except to a very limited number of
subscribers.

In certain other countries, no provision at all is
made for making such meter pulses available to
30 subscribers and, in such countries, the subscriber
has no means of determining the cost of calls
except by utilising a stop watch and referring to
his directory for the appropriate cost information.

It is an object of the present invention to
35 provide a telephone call cost calculator for use by
subscribers which does not require any metering
information from the exchange.

According to this invention, a calculator for
determining and indicating the cost of telephone
40 calls from subscriber apparatus comprises a data
processor a memory operatively associated with
the data processor and storing program
instructions therefor and also data defining call
charge rates, data input means for connection to
45 the subscriber telephone apparatus arranged for
feeding to the data processor signals generated
by the subscriber for making a telephone call, the
data processor being programmed to compare
said signals with stored information to determine
50 the appropriate charge rate, initiate means for
providing an initiate signal for initiating timing of
the call, means operative on termination of the
call for terminating the timing, the data processor
being arranged furthermore to determine the
55 charge for a call from the predetermined charge
rate and the determined time period and display
means for indicating the cost of the call. The
display means are most conveniently arranged to
display the cost in monetary units but the
60 calculation may be effected in terms of arbitrary
units such as are employed by the telephone
authority for calculating charges. Preferably the
display means is arranged for displaying the cost

of an individual call and/or the cumulative cost of
65 calls over a period.

The data processor is very conveniently a
microprocessor but it is possible to use other
devices which are suitably programmed, e.g. an
uncommitted logic array or a dedicated "chip". In
70 the following description, the word "processor"
will be used to include all such devices.

Telephone authorities usually employ a limited
number of charge rates. Commonly these rates
will depend on the destination of the call and they
75 may also depend on time of day etc. In the United
Kingdom, the destination of the call, with present
charging arrangements, would have to be
deteremined as one of six possibilities, namely an
overseas call, or local call or, if the call is not
80 either of these, whether it is charged at the (a),
(b), (b1) or (c) rates, (use of the (c) band at present
is in abeyance). Overseas calls are sub-divided
furthermore into a plurality of different charge
bands. In other countries, the apparatus will have
85 to be arranged to take into account the charging
system employed in that country. In the present
specification, reference will be made more
particularly to the conditions in the United
Kingdom; it will however be readily apparent to
90 those skilled in the art how to adapt such
arrangements to suit different charging regimes.

In the U.K. an overseas call is identified by the
first three dialling digits being 010. If such digits
are dialled, then the selection of the appropriate
95 overseas charge band from the memory can then
be determined from the next one or next few
digits. Local calls commonly also are readily
identifiable from the first few digits of the dialled
number which again will uniquely define that a
100 call is a local call. In the United Kingdom, the (a),
(b1) and the (c) charge bands will in general have
relatively few numbers which would have to be
stored in the memory. All calls not identified as
being overseas or local or in the (a), (b1) or (c)
105 charge bands can then be assumed to be in the
(b) charge band. The memory requirements thus
are not very onerous in this respect and it is
readily possible to store the identification of the
charge bands in a read-only memory or in a
110 random access memory which is programmed on
installation.

Having determined the charge band, the
appropriate charge rate for the time of day has to
be determined and for this purpose, a
115 clock/calender may be employed, the calender
being pre-programmed, for example to indicate
Saturdays, Sundays and holidays when cheaper
charge rates are available. A separate clock
calender unit with a crystal oscillator may be
120 provided for interrogation by the data processor
when the time data is required.

The data processor, in response to the initiate
signal, may provide clock pulses at a
predetermined rate, and at each clock pulse, the
125 data processor may be arranged to implement the
contents of a memory location by an amount
determined by the call charge rate. Alternatively
the data processor, in response to the initiate

signal may provide pulses at a rate in accordance with the selected charge rate so that the number of pulses is proportional to the computed charge.

5 In some circumstances, the initiate signal may be provided by means determining the establishment of a connection to the called subscriber, e.g. by sensing the end of a ringing signal or by sensing the establishment of voice communication. For simplicity however and 10 economy, it will generally be more convenient to provide on the apparatus a button for operation by the subscriber when the charging period, for which he requires indication of charge, commences.

15 It may be preferred however to employ automatic means providing the initiate signal, for example after a predetermined time period which is chosen for example to represent the average delay in completion of a connection to a called 20 subscriber. The time period may be determined from the end of the dialling signal or making use of the ringing tone which can be sensed. Such automatic means utilising an average value of a delay period may lead to minor variations 25 between the computed charge and the true cost of a call but provides a very simple and convenient way of ensuring that recording is made of the accumulated charge for every call. Other ways will be readily apparent of ensuring 30 recording of charging for each call; for example in a system having a push-button, means may be provided for inhibiting transmission from the calling subscriber until the button has been operated.

35 Power for operation of the call cost calculator may in some cases be derived from the telephone lines (where this is practical and is permitted by the telephone authority). Alternatively the telephone subscriber may provide the power, for 40 example from the electricity supply mains. In either case, protection against supply interruption may be provided by means of standby battery.

The apparatus described above may readily be adapted for use with pay telephones or with credit 45 card telephones. For a pay phone, particularly modern types of telephone which can accept a coin or coins and give change at the end of a call if the inserted money is in excess of the actual cost of the call, the above-described apparatus 50 may be used, in place of present-day techniques requiring metering pulses from the exchange, to compute and indicate the cost of the call. More generally however the apparatus may be used in a pay phone for requesting insertion of further coins 55 and for terminating the call at the end of the period paid for.

In a credit card telephone, the above-described apparatus facilitates the use of a permanent card bearing information, e.g. in a magnetic strip, 60 identifying the account to which calls by the card user are to be charged. The above-described apparatus can be used to compute the charge and, at the end of a call, the computed charge is transmitted to the exchange in digital form 65 together with required account data read from the card and the card is then released and returned to the user.

The apparatus also may be used at a PBX and, in this case, means may be provided for recording. 70 e.g. by printing a read-out tape or the like, data on call with information as to the calling extension, called number, etc.

In the following description of one example of the invention, reference is made to the 75 accompanying drawings in which:—

Figure 1 is a block schematic diagram of a telephone call cost calculator;

Figure 2 is a simplified circuit diagram illustrating one form of circuit for providing an 80 initiate signal; and

Figures 3 and 4 are operational flow charts for explaining the functional operation of the processor for charge computing and for validating dialling impulses respectively.

85 Referring to Figure 1 there is shown diagrammatically a microprocessor unit 10 connected to a data bus 12 and a memory address bus 13. Connected also to these buses are a look-up read-only memory 14, a charge rate 90 programmable read-only memory 15, a further programmable read-only memory 16 and a scratch pad random access memory 17.

The subscriber's telephone apparatus is indicated diagrammatically at 20 and includes 95 means 21 for feeding calling signals, which in the United Kingdom are dialling pulses, to input signal conditioning apparatus 22 which converts the dial pulses into signals compatible with the microprocessor 10 and also provides a signal indicative 100 of the line condition at the subscriber apparatus 20. These signals are provided to a display control 23 and also to an input port 24 which, via the data bus 12 provides these signals for use by the central processor unit 10.

105 In response to a signal from unit 22 indicative of the line condition and showing that the receiver has been lifted off the hook, the display control 23 provides a signal to one of four external flag inputs EF1—4 on the microprocessor 10. 110 Typically this flag input is "high" if the subscriber apparatus is "on hook" and is "low" if the subscriber apparatus is "off hook". In this way the microprocessor 10 senses the condition of the line at the subscriber apparatus 20 and therefore 115 detects when a user is about to dial the calling code.

The microprocessor 10 is controlled by a clock divider 30 and is programmed to examine the status of flag inputs EF1—4 at a predetermined 120 rate. When a user dials a calling code from the subscriber apparatus 20, the microprocessor first detects, on one of these inputs, say EF1, which indicates "off hook", a logic 0 indicating that the apparatus is off-hook and then a logic 1 indicating 125 either a dialling pulse or reinstatement of the "on-hook" condition. It determines, in the micro-program instructions, that the 1 existed for an appropriate time (say at least (50 ms) followed by a 0 for an appropriate time (say at least 35 130 ms). If the flag input EF1 goes high again, for say

more than 80 ms, it is deemed that the
receiver is placed back on the hook, and then the
procedure reverts to the beginning again. If, on
the other hand, a valid dial pulse has been found,
5 that is to say, a logic 1 of more than say 50 ms
and less than say 80 ms, the dial pulses which are
now applied via the input port are examined. Each
dial pulse increments a register within the micro-
processor 10 and, after a 0 has existed on EF1 for
10 say 200 ms, which is approximately half the
duration of the interdigital pause (IDP) the micro-
processor assumes that the count for that dial
digit is complete. The validation check is thus on
both mark and space. It will be appreciated that
15 these time durations for validating the information
are chosen in accordance with the standard mark
and space durations used by the telephone
authority. Much higher rates of pulses may be
used in some systems. The contents of the
20 register storing the pulse counts are then
transferred to a first digit slot in the afore-
mentioned random access memory module 17
and the microprocessor advances to determine
the second digit and so on. This continues until
25 the microprocessor has extracted all the digits
required for defining the appropriate charge rate
for the call. It will be appreciated that, in general,
only the first few digits of a dialled code would be
required for this purpose. These digits are then
30 compared with stored information in the afore-
mentioned look-up read-only memory 14. As
previously explained, this read-only memory need
not store all possible codes since for example, an
overseas call can be identified by the dialling code
35 prefix 010 and the overseas charge band can then
be identified from the next or the next two or
possibly three digits. Many or possibly all local
calls can be identified by the absence of an 0 from
the beginning of the dialling code. The remaining
40 calls starting with a prefix 0 which is not followed
by 10 can be analysed so far as the U.K. is
concerned, very conveniently by checking
whether certain called numbers defining
exchanges in band (a), (b1) and band (c) have
45 been called and assuming that any other called
number must therefore be in band (b).
       When the charging band has been determined,
the microprocessor then has to investigate the
temporal status in all cases where the actual
50 charging rate depends on the time of day. The
clock divider 30 drives a clock/calendar unit
within the program of the microprocessor 10
which establishes the time/day information and
via the charge rate programmable read-only
55 memory 15 provides the actual charging rate
information to the data bus 12 for feeding to the
microprocessor. The clock/calendar contains not
only time and day of the week but also specific
days such as Bank Holidays where the charge
60 rates differ from normal. The clock divider unit 30
might incorporate a crystal oscillator and might
be connected to the data bus 12 so that time
information is available by interrupt of a wait
state of the microprocessor. In the embodiment
65 illustrated, the microprocessor unit 10 has an

internal crystal clock circuit 40 and the external
clock divider unit 30 comprises a divider which
produces interrupt signals to the microprocessor
at intervals of say 0.1 seconds. The divider might
70 be arranged to modify these time intervals in
accordance with charge rate demands. The
programmable read-only memory services such
requests for time information and increments the
time and date data which is held in the scratch
75 pad random access memory.
       The computation of the charge requires
determination not only of the charge rate but also
of the duration of the call. Initiate means 41 feed
an initiating signal into the display control 23 and
80 thus sets one of the flag inputs of the micro-
processor 10. Termination of the call is most
conveniently detected by the replacing of the
subscriber receiver on the hook so giving the on-
hook condition signal via input conditioning unit
85 22 and display control 23 to a flag input of the
microprocessor.
       As previously explained, the initiate signal may
be derived in a number of different ways and
commonly it may be preferred to make use of one
90 or a combination of sources of the initiate signal.
One simple way of producing the initiate signal is
illustrated in Figure 2. This figure shows the
initiate means 41 of Figure 1 together with part of
the telephone apparatus 20. Essentially it has a
95 switch 42, conveniently a push-button switch
with automatic spring return, which provides a set
signal for a bistable 43 which bistable is
automatically reset by an "on hook" signal on a
lead 44. Setting of the bistable closes a switch 45
100 in the transmission circuit from the microphone
47 of the telephone apparatus to the transmission
output terminals 48 of the transmission circuit
from the microphone. Thus the transmission
circuit from the microphone is only completed on
105 operation of the switch 42. The condition of the
bistable is also transmitted via a lead 49 to one of
the flag inputs of the microprocessor, this flag
input being referred to as the initialisation flag.
With this arrangement, the subscriber cannot
110 speak to the called subscriber until the push-
button 42 has been operated. At the end of the
call, replacement of the receiver on the hook
resets the bistable 43 and so releases switch 45
but closes switch 46 to incorporate an impedance
115 50 in the transmission circuit equivalent to the
microphone impedance to avoid disturbing the
line conditions.
       It will be appreciated however that there are
many other possible ways of providing an initiate
120 signal. If it is desired to avoid any modification of
the telephone apparatus and thus not to have the
transmission inhibit facility, it is still possible to
use a push-button to provide the initiate signal
but, in this case, it may be preferred to provide an
125 additional source of this signal so that cost
calculation is effected even if the button is not
operated. In some cases it may be convenient to
make use of a signal derived from the exchange
and passed down the calling subscriber's line. If
130 signal exists in the calling subscriber's exchange

to initiate charging there this signal could be imposed on the line more simply than feeding meter pulses. A transient line polarity reversal, for example, would serve the purpose and be simple

5 to implement in the exchange. However, the use of the push-button switch 42 obviates any need to modify exchange equipment in any way. Other more complex techniques may be employed which obviate the necessity for manual operation

10 of the push-button 42. For example equipment could be provided which recognises the differences between impulses dialling or tone dialling and speech on the line. Then a simple time analysis, consisting of repetitive interrogation of

15 the external flag could produce information that speech is present rather than any other system condition and this recognition of speech can be used to initiate the timing.

Power for the device may in some cases be

20 provided from the telephone line. In this case the system would be in a stand-by low power state until awakened by an interrupt from the clock divider. Alternatively the subscriber's domestic alternating power supply might be used. In either

25 case, any volatile memory can be protected from supply interruption by battery operation in a "stand-by" mode.

The computed output information is fed from the microprocessor via data bus 12 and an output

30 port 52 to a display unit 53, conveniently a liquid crystal display with seven segment display units. These require an alternating current feed and the data decoders can conveniently be fed with clock pulses derived from the clock/calender circuitry.

35 Figure 3 is a flow diagram for explaining the programming of the microprocessor. This program which starts from the indication that the subscriber has lifted his receiver off the hook essentially validates the dialling digits and having

40 checked the initial digits determines whether the dialling code is for an overseas call, or for an internal call. If it is for an overseas call, the next three digits are entered and these are then analysed to determine the appropriate charge

45 band. If the call is not an overseas call, a check is made as to whether the first digit is a 0 or not a 0. If it is a 0, the call is generally not a local call. If the first digit is a 0, the next digits are compared with the stored information to obtain the charge

50 band. This part of the flow diagram will now be explained in further detail.

When a number is dialled its first three digits are temporarily put, under microprocessor program control, into a register. These first three

55 digits of the number are then compared with a plurality of permanently stored conditions to establish the start point of a search. One search is initiated by 010, the overseas code. Any other combination of digits after zero for the next digits

60 indicates that the call is not an overseas call. In the U.K., in general, the absence of an 0 as the first digit is indication that the call is a local call and no further identification is required. If the first digit is an 0, which is not followed by 10, then the

65 first few digits will have to be checked against

stored information to determine the charge band, that is (a), (b) or (b1) under present arrangements. If the first three digits are 010 (foreign code) then the dial validation continues to establish the

70 second three digits. These will be sufficient to determine the charge band.

Since in general only three digits after the initial zero are required to identify the charge band, a two byte system may be employed, the

75 first byte holding the first two digits of the code and the second byte holding the third digit of the code in the upper nibble, the lower nibble carrying the charge band information.

Whichever branch in the microprocessor

80 program takes place an area of memory conveniently, but not necessarily, semi-conductor electrically programmable and ultra violet erasable read-only memory is scanned step by step until coincidence is achieved. When this

85 occurs the lower nibble of the second byte is extracted and transferred into a microprocessor register. This is the charge band code. When the charge band code has been extracted the program branches to investigate the temporal status by

90 interrogation of the clock. Thus having established the particular charge band, the time/day information routes the calculation to the relevant charge information. The clock information contains not only time and day of the

95 week, but certain specific days such as Saturdays and Sundays and Bank Holidays and other days, to which discount rates apply. The charge is indicated on a four or five digit L.C.D. display.

The validation of the dial pulses has been

100 briefly described previously. As shown in Figure 4, this is effected by soft-ware programming of the microprocessor. Dial pulses consist of a defined mark/space ratio of make/break across the line at a defined pulse rate. In the U.K. the rate is 10 i.p.s.

105 with M/S of 60:40. The input conditioning takes these 50v (in U.K.) pulses and translates them to a C.P.U.—compatible level (say 5v). Dialled number validation is carried out as follows:— The line condition can be sensed in a number of ways

110 by the C.P.U., one convenient method being through one of the four external flags (E.F.). There are a number of conditional branch routines dependent upon the state of the flag, and this is a convenient facility.

115 On hook E.F.+1 (i.e. line voltage high)
Off hook E.F.=0

So the state of the line can be interrogated by the C.P.U. The program would detect first a '1', check that '1' exists for an appropriate time (say

120 at least 50 ms) followed by a zero for an appropriate time (say 35 ms). A previously zeroed register is then incremented. E.F. is intermittently interrogated thereafter. If E.F. goes high again, within, say, 50 ms, the procedure is repeated, and

125 the register accumulates the dialled digit as the pulses are validated. Various levels of additional security of validation can readily be introduced, though this is generally more relevant when recording the dialled number remotely, e.g. the

130 exchange end of the line, more prone to spurious

data. For example E.F. can be checked repetitively
(say every 1 ms) to confirm that it was
. continuously in that state for a given time. It can
be checked on the basis of 'n' consecutive
5 answers being the same—or a majority vote—and
so on, depending upon the sophistication required.
All that is required is a very little additional software.
If a zero state exists for say 200 ms nearly half the
I.D.P.—then the count for that digit is complete,
10 the register content is transferred to the "first
digit" slot in memory, and the system is ready to
interrogate the second digit, and so on.
     While a system for the U.K has been described,
although the situation may be different in other
15 countries in terms of the rate of impulsing,
Mark/Space ratio, and I.D.P., this only requires
different constants in the validation part of the
program. In some instances, systems other than
"loop disconnect" are employed for dialling, e.g.
20 M.F. tone dialling. In these instances the device
contains an appropriate decoder inserted in the
system before the validation circuitry.
     After the first three digits the C.P.U. compares
these with the stored codes, and quickly decides if
25 they amount to "010" (which it can do very
readily with the I.D.P.) and if 'yes' it requires
another three digits. If 'no' it proceeds with the
main search, as described previously.
     Having determined the charge bands, the
30 clock/calendar information must be obtained to
define the charge rate and the call time duration
must be determined from the initiate signal and
the termination signal which signals are obtained
as previously described. The microprocessor then
35 has to determine the running cost which is
displayed on the display 53 as the cost of the call
in progress. The display unit would normally have
control means, e.g. a switch to enable the
subscriber to display the cumulative cost of all
40 calls since the cumulative cost adder was last
reset.
     The apparatus described above finds particular
application in association with or as part of a pay
telephone. It may be used automatically not only
45 to compute and display the running cost of a call
being made but also to control the payment
mechanism, e.g. to signal for the user to insert
further money. It will be noted that the above-
described apparatus permits this to be done
50 without requiring the transmission of metering
impulses from the exchange to the telephone
apparatus. This, in particular, facilitates the
installation of pay telephones in hotels and other
establishments as such a pay telephone can
55 operate without requiring any special facilities at
the exchange. Moreover, the telephone owner can
set the charges for payment of telephone calls as
desired without making use of any charge
computing facilities of the telephone authority.
60 The apparatus furthermore facilitates the
provision of facilities for paying for telephone calls
using a credit card, particularly a card having data,
e.g. on a magnetic strip, identifying an account to
be charged. The computer charge and other data

65 may, for example, be transmitted at the end of a
call to the exchange or a billing station.

Claims

1. A calculator for determining and indicating
the cost of telephone calls from subscriber
70 apparatus, which calculator comprises a data
processor, a memory operatively associated with
the data processor and storing program
instructions therefor and also data defining call
charge rates, data input means for connection to
75 the subscriber telephone apparatus arranged for
feeding to the data processor signals generated by .
the subscriber for making a telephone call, the data
processor being programmed to compare said
signals with stored information to determine the
80 appropriate charge rate, initiate means for
providing an initiate signal for initiating timing of
the call, means operative on termination of the
call for terminating the timing, the data processor
being arranged furthermore to determine the
85 charge for a call from the predetermined charge
rate and the determined time period and display
means for indicating the cost of the call.
2. A calculator as claimed in claim 1 wherein
the data processor is a microprocessor.
90 3. A calculator as claimed in either claim 1 or
claim 2 wherein the display means are arranged
to display the determined cost in monetary units.
4. A calculator as claimed in any of the
preceding claims wherein the display means are
95 arranged for selectively displaying the cost of an
individual call and the cumulative cost of calls
over a period.
5. A calculator as claimed in any of the
preceding claims wherein the data processor, in
100 response to the initiate signal, provides pulses, at
a rate determined by the ascertained call charge
rate so that each pulse corresponds to a unit of
charge, to increment the contents of a memory
location, such that said contents will represent
105 the current cost of the call.
6. A calculator as claimed in any of claims 1 to
4 wherein the data processor, in response to the
inititate signal, provides a clock pulse at a pre-
determined rate, so that each pulse corresponds
110 to a unit of time, to increment the contents of a
memory location, at each clock pulse, by an
amount in accordance with the determined call
charge rate whereby the contents of the memory
location represent the current cost of the call.
115 7. A calculator as claimed in any of the
preceding claims wherein the initiate signal is
provided by means sensing when the called
subscriber has gone off hook.
8. A calculator as claimed in any of claims 1 to
120 6 wherein the initiate signal is provided by means
sensing the completion of the connection to the
called subscriber.
9. A calculator as claimed in any of claims 1 to
6 wherein the initiate signal is provided by means
125 sensing the end of the ringing tone on completion
of the connection.
10. A calculator as claimed in any of claims 1
to 6 wherein means are provided for sensing the

ringing tone on completion of the connection and wherein the initiate pulse is provided by delay means for delaying the initiate signal until a predetermined time period after sensing the
5 ringing tone.

11. A calculator as claimed in any of claims 1 to 6 and having means responsive to the sensed completion of dialling for generating the initiate signal.

10 12. A calculator as claimed in any of claims 1 to 6 wherein the initiate signal is provided by means responsive to dialling pulses and including delay means for delaying the initiate signal for a predetermined time period after sensing the
15 completion of dialling.

13. A calculator as claimed in any of the preceding claims and having a subscriber-operated push-button or key for generating the initiate signal.

20 14. A calculator as claimed in claim 13 wherein means are provided inhibiting transmission from the calling subscriber until the push-button or key is operated.

15. A calculator as claimed in any of the
25 preceding claims wherein the means for determining the appropriate charge rate comprises means for determining the appropriate charge band together with a clock/calendar, the calendar being pre-programmed, to indicate days
30 and time-periods during days when cheaper charge rates are available.

16. A calculator as claimed in any of the preceding claims wherein a call-terminate signal is provided to said microprocessor from the hook-

35 switch of the subscriber apparatus.

17. A calculator as claimed in any of the preceding claims wherein at least part of the memory is an electrically programmable read-only memory.

40 18. A calculator as claimed in any of the preceding claims and wherein said data processor is arranged to validate sensed dialling pulses by checking that both mark and space periods fall within predetermined limits of duration.

45 19. A calculator as claimed in any of the preceding claims and arranged for use with a pay telephone wherein the display means are arranged to indicate the running cost of a call in progress.

50 20. A calculator as claimed in claim 19 and arranged to control the call duration in accordance with payments made by insertion of coins.

21. A calculator as claimed in any of claims 1
55 to 18 and in combination with credit card payment telephone wherein the calculator is arranged to accept a card bearing encoded information identifying an account to which a call is to be charged and wherein means are provided
60 operative, at the termination of a call, to transmit data, from the telephone to an exchange or billing station, representative of the determined cost of the call and of the account to be charged.

22. A calculator for determining and indicating
65 the cost of a telephone call or calls from subscriber apparatus substantially as hereinbefore described with reference to the accompanying drawings.